92-297

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FEDERAL COMMUNICATIONS COMMISSION
INTERNATIONAL BUREAU
Satellite and Radiocommunication Division

DOCKET FILE COPY ORIGINAL

memorandum

December 14, 1995

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To: William S. Caton, Acting Secretary

From: Jennifer M. Gilsenan JMG

Re: CC Docket No. 92-297

On December 14, the International Bureau's Satellite and Radiocommunication Division convened a meeting with the participants listed in attachment A to this memorandum. The participants discussed interservice frequency sharing rules. The attached documents as well as previous submissions to the record formed a basis of the discussions.

Motorola / TRW meeting

12/14/95

Name	Organization	Phone/Fax
Jennifer Gilsenan	FCC	418-0757 / 418-0[illegible]
Norm Leventhal	LS+L for TRW	416-6744 / 293-778[illegible]
Richard Barnett	Consultant to TRW	(301) 229-0204 / 320-2421
Steve Baruch	L,S&L / TRW	202 416 6782 / 202 293 7783
Roger Rusch	TRW Odyssey	(310) 812-2424 / 310 814-1400
Hau H. Ho	TRW odyssey	(310) 8121656 / 814[illegible]
PHILIP MALET	STEPTOE + JOHNSON	(202) 371-6893 / 8423578
David Carroll	motorola	602 732-4918 / 732-2305
Barry Lambergman	Motorola	202-371-6929 / 842-3578
Richard Stone	Motorola	(602) 732-3991 / 2305
THOMAS S. TYCZ	FCC	202-418-0735 / 418-0748
Karl Kensinger	FCC	(202) 418-0773 / 418-0765
HARRY NG	FCC	(202) 418-[illegible] / 418-0765
Giselle Gomez	FCC	202-418-0755 / 418-0765
Ron Repasi	FCC	202 418 0768 / 418-0765
Peter Hadinger	TRW	703 2765156 / 276-5029

$No = -197.5$

Io	(No + Io) (dB)	DELTA
-195.5	-193.38	4.12
-196.5	-193.96	3.54
-197.5	-194.5	3.0
-198.5	-194.96	2.54
-199.5	-195.38	2.12
-200.5	-195.74	1.76
-201.5	-196.04	1.46
-202.5	-196.31	1.19
-203.5	-196.53	0.97
-204.5	-196.71	0.79
-205.5	-196.86	0.64
-206.5	-196.99	0.51
-207.5	-197.09	0.41

Sharing analysis between two NGSO systems

Could you please address the following items relating to the December 13, 1995 paper by Hau Ho. A better understanding of these issues will facilitate a discussion of the paper and understanding of the necessary sharing conditions between two NGSO satellite systems.

1) Please document the simulation methodology upon which the paper is based. A detailed description of the methodology utilized along with any assumptions used in the application of that methodology (i.e. if power control is used, how is it implemented; if antenna polarization is used, when and how is it applied). The input paper has very little detail in this respect.

2) Define the input parameters to the model. For example the following parameters may need to be considered:

Number of satellites	Number of orbital planes
Number of satellites per plane	Altitude of satellites
Inclination of satellites	Frequency range
Receive/transmit bandwidth	Receive/transmit antenna gain
Peak transmit power	Power control strategies
Location of ground station	Simulation time parameters
Receiver noise temperatures	

(It is recognized that a number of these parameters are included in the paper, however, they are included here for completeness)

3) Please describe the expected output of the simulation. An example is the % time that the interference level is above the noise floor (Io/No) (since one of the systems is a CDMA system, is it appropriate to relate this interference level (Io/No) to loss of capacity?).

4) The input paper shows only a few Io/No points; if more were included, a more comprehensive depiction of the results would be provided.

5) The interpretation of figures such as Figure 3-6 is not clear. How are these figures related to the conclusions?

6) Describe the relationship between the separation angles in the two right-hand columns in Figures 3-1 (0.58 and 1.0 degrees) and Figure 3-2 (3.8 & 10 degrees). Are these related to a proposed mitigation technique?

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LAW OFFICES
LEVENTHAL, SENTER & LERMAN
SUITE 600
2000 K STREET, N.W.
WASHINGTON, D.C. 20006-1809

NORMAN P. LEVENTHAL
MEREDITH S. SENTER, JR.
STEVEN ALMAN LERMAN
RAUL R. RODRIGUEZ
DENNIS P. CORBETT
BRIAN M. MADDEN
BARBARA K. GARDNER
STEPHEN D. BARUCH
SALLY A. BUCKMAN
NANCY L. WOLF
DAVID S. KEIR
DEBORAH R. COLEMAN
BERNARD A. SOLNIK**
NANCY A. ORY
WALTER P. JACOB
LINDA D. FELDMANN
RENÉE L. ROLAND*

*ADMITTED MD ONLY
**ADMITTED NY & CT ONLY

TELEPHONE
(202) 429-8970

TELECOPIER
(202) 293-7783

SENIOR COMMUNICATIONS CONSULTANT
MORTON I. HAMBURG

December 11, 1995

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OFFICE OF SECRETARY

BY HAND DELIVERY

Barry Lambergman, Esq.
Motorola, Inc.
1350 Eye Street, N.W.
Suite 400
Washington, D.C. 20005

Re: Updated NGSO MSS Feeder Link Sharing Analysis for the 29.1-29.4 GHz and 19.3-19.6 GHz Bands

Dear Barry:

Enclosed, as promised, is an update of TRW's sharing analysis for two NGSO MSS feeder link networks operating on a co-directional basis in the 29.1-29.4 GHz and 19.3-19.6 GHz bands. See Attachment 1. A facsimile version of the update is the best copy available today; a hard copy will be forwarded to you tomorrow.

This analysis is a revision of the study TRW appended to its September 7, 1995 Comments in response to the Commission's Third NPRM in CC Docket No. 92-297, and addresses both the criticisms cited by Motorola, et al. in their October 10 Joint Reply Comments in the same proceeding, and the outcome of the just-completed World Radiocommunication Conference. TRW continues to believe that co-frequency, co-directional sharing between the Odyssey™ and Iridium™ systems' feeder links is feasible in the Ka-Band spectrum designated for such use at WRC-95, and can be implemented on an intersystem coordination basis. As TRW will require a maximum of two feeder link earth station complexes to cover North America, it feels that the regulatory framework TRW proposed in its Comments on the CC Docket No. 92-297 Third NPRM is a reasonable starting point for discussions, and could readily be fine-tuned to accommodate any earth-station siting plan Motorola and/or Iridium may be contemplating. A copy of TRW's September 1995 rule proposals relating to sharing between Odyssey and Iridium, and between the NGSO/MSS feeder links at Ka-Band and the proposed LMDS service, is included in Attachment 2 to this paper.

If you have any questions or desire any clarifications concerning either of the attached documents, please do not hesitate to call. We look forward to a constructive and productive session with you and your colleagues at the Commission on Thursday.

Sincerely,

Stephen D. Baruch
Attorney for TRW Inc.

Enclosures:

cc (w/encl.):	Thomas Tycz	(By Hand)
	Cecily Holiday	(By Hand)
	Harry Ng	(By Hand)
	Karl Kensinger	(By Hand)
	Giselle Gomez	(By Hand)
	Jennifer Gilsenan	(By Hand)
	Philip Malet, Esq.	(By Hand)
	John Knudsen	(By Facsimile)
	Tim Klandrud	(By Facsimile)
	Rob Kubik	(By Facsimile)
	Melvin Barmat	(By Hand)

ATTACHMENT 1

December 11, 1995

Authors: Hau H. Ho
TRW/ Odyssey™
Phone: (310)812-1656
Facsimile: (310)814-1400

Co-Directional Frequency Sharing Between the Odyssey™ and the Iridium NGSO MSS Feeder Links Systems in the 29.1 - 29.4 GHz and 19.3 - 19.6 GHz Bands

1.0 Introduction

This paper presents analysis and simulation results related to the feasibility of co-directional frequency sharing between the Odyssey™ and the Iridium NGSO MSS feeder link systems in the 29.1 - 29.4 GHz and 19.3 - 19.6 GHz bands. The analysis and simulation of these systems and "in-line" interference events provided valuable information to determine the feasibility of co-directional frequency sharing between these systems. "In-line" interference occurs when two satellites are close enough in the line of sight to interfere with each other.

2.0 Technical Characteristics of Satellite Systems

The Odyssey™ system constellation is comprised of twelve satellites in three orbital planes at an inclination of 50 degrees to the equatorial plane. Each satellite is placed in circular orbit at an altitude of 10355 Km. The Odyssey™ system uses the spectrum in the band 1610 to 1626.5 MHz for the mobile return link from the user to the satellite. The mobile forward link from the satellite to the user uses the band 2483.5 to 2500.0 MHz.

As the result of spectrum actions taken at WRC-95, TRW now expects that it will be formally licensed to use the band 19.3 - 19.6 GHz and 29.1 - 29.4 GHz bands for the feeder return link from the satellite to earth station and feeder forward link from earth station to satellite, respectively. These frequency bands are currently allocated for FSS, and were designated for use by NGSO MSS feeder links at WRC-95.

The satellite payload functions as a simple bent pipe, frequency translating transponder. For the mobile link, each satellite has the multi beam antenna with 40° field-of-coverage. In the feeder link, each satellite has three independent steerable antennas with spot beams for both transmitting and receiving signals to/from multiple gateways. The 3 dB beamwidth of the transmit and receive antennas are 3° and 2.2°, respectively.

The Iridium system constellation is comprised of 66 satellites in six near-polar orbits with an inclination angle 86.4° and an altitude of approximately 787 Km above the Earth. The Iridium system uses spectrum in the band 1610 to 1626.5 MHz for the mobile return user to satellite link and mobile forward satellite to user link. The Iridium system would use the 19.4 to 19.6 GHz and 29.1 to 29.3 GHz bands for the feeder return link from the satellite to the earth station and feeder forward link from earth station to satellite, respectively. For the mobile link, each satellite has a 48 beam antenna with 126° field-of-coverage.

The orbital characteristics of the Odyssey™ system and the Iridium system are given in Table 2.1.

Table 2.2 shows the satellite communication system parameters

Table 2.3 shows the earth station communication system parameters

Table 2.1: Orbital Parameters

Parameters	Odyssey (NGSO MSS)	Iridium (NGSO MSS)
Number of satellites	12	66
Number of orbital planes	3	6
Number of satellite/plane	4	11
Altitude	10355 Km	787 Km
Inclination angle	50°	86.4°
Period of orbit	5.98 hours	1 hour and 40 minutes

Table 2.2: Satellite Communication System Parameters (Feeder links)

Satellite Parameters	Odyssey (NGSO MSS) (Feeder links)	Iridium (NGSO MSS) (Feeder links)
Receive frequency range	29.1 to 29.4 GHz	29.1 to 29.3 GHz
Receive bandwidth	300.0 MHz	200.0 MHz
Receive Polarization	LHCP	RHCP
Receive antenna gain (Peak)	38.5 dBi	30.1 dBi
3 dB beamwidth	2.2°	5.7°
Receive total system noise Temperature	780° K or 28.9 dB-K	1295.5° K or 31.1 dB-K
Transmit frequency range	19.3 to 19.6 GHz	19.4 to 19.6 GHz
Transmit bandwidth	300.0 MHz	200.0 MHz
Transmit Polarization	RHCP	LHCP
Transmit AEIRP (Peak) Transmit Signal AEIRP	46.4 dBW -37.0 dBW	13.5 to 23.2 dBW/ per channel
Transmit antenna gain	35.7 dBi	26.9 dBi
3 dB beamwidth	3.0°	8.27°
Transmit power density into antenna	-65 dBW/Hz (peak)	-77.8 to -67.9 dBW/Hz

Table 2.3: Earth Station/User Communication System Parameters (Feederlinks)

Earth Station/ User Parameters	Odyssey (NGSO MSS) (Feederlinks)	Iridium (NGSO MSS) (Feederlinks)
Transmit frequency range	29.1 to 29.4 GHz	29.1 to 29.3 GHz
Transmit bandwidth	300.0 MHz	200.0 MHz
Transmit Polarization	LHCP	RHCP
Transmit EIRP	85.9 dBW (peak)	68 dBW (peak)
Transmit antenna gain	64.8 dBi	56.3 dBi
3 dB Beamwidth	0.11°	0.28°
Transmit power density into antenna	-55.49 dBW/Hz (peak)	-52.9 dBW/Hz (peak)
Receive frequency range	19.3 to 19.6 GHz	19.4 to 19.6 GHz
Receive bandwidth	300.0 MHz	200.0 MHz
Receive Polarization	RHCP	LHCP
Receive antenna gain	60.8 dBi	53.2 dBi
3 dB Beamwidth	0.17°	0.40°
Receive antenna noise temperature	666.5 °K or 28.2 dB-K	731.4° K

2.1 The Odyssey™ and the Iridium Antenna Patterns

2.1.1 Earth Station Antenna Patterns

The Odyssey™ earth station transmit and receive antenna patterns are shown in Figures 2-1 & 2-2, respectively.

The Iridium earth station transmit and receive antenna patterns are shown in Figures 2-3 & 2-4, respectively.

2.1.2 Satellite Antenna Patterns

Figures 2-5 and 2-6 show the Odyssey™ and the Iridium satellite antenna patterns, respectively.

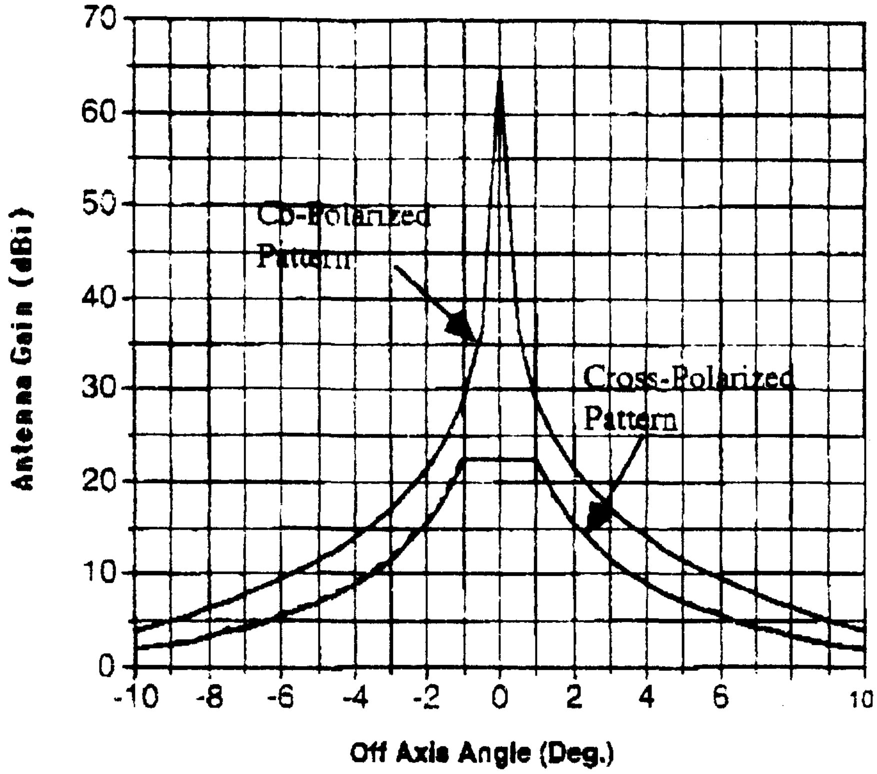


Figure 2-1: The Odyssey™ E/S Transmit Co & Cross-Polarized Antenna Patterns (Based on CCIR Rec. No. 580 & 731)

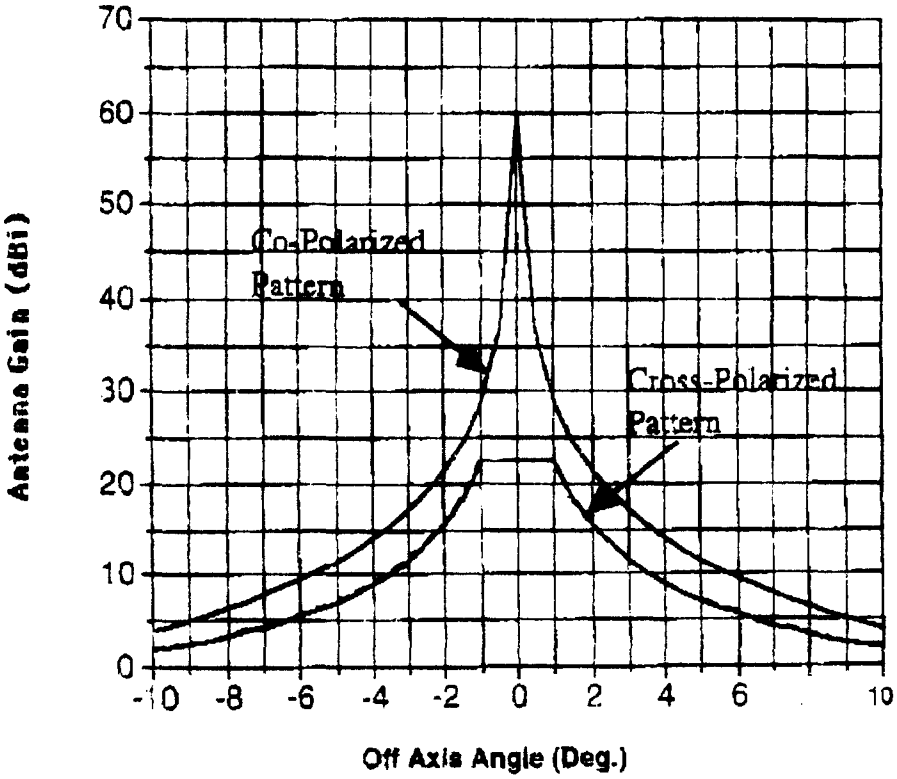


Figure 2-2: The Odyssey™ E/S Receive Co & Cross-Polarized Antenna Patterns (Based on CCIR Rec. No. 580 & 731)

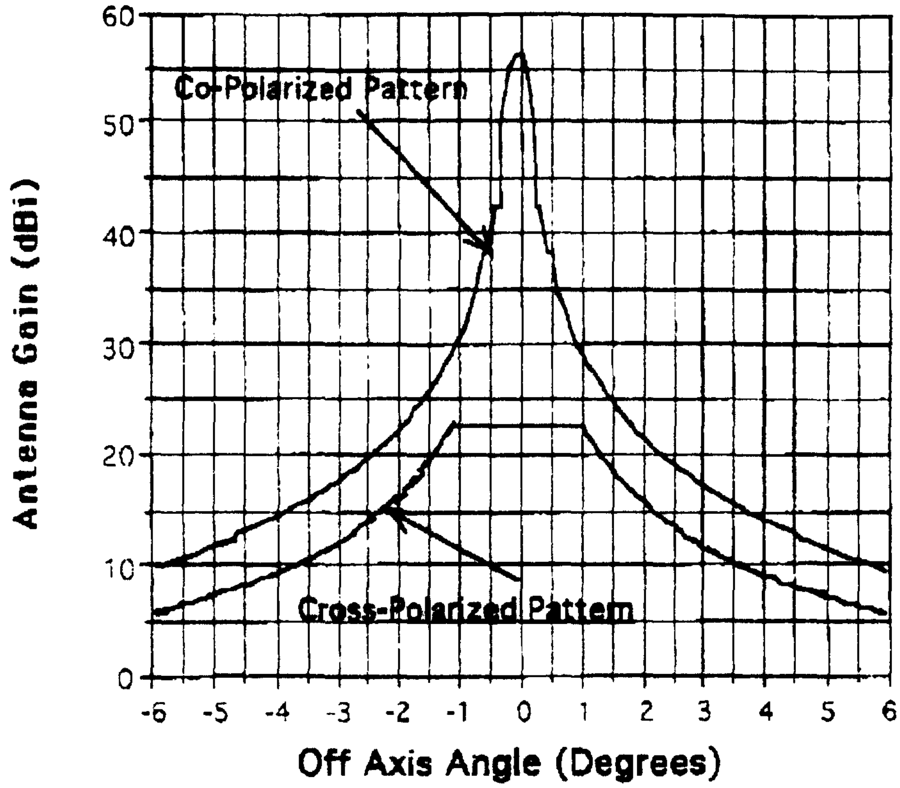


Figure 2-3: The Iridium E/S Transmit Co & Cross-Polarized Antenna Patterns
(Based on CCIR Rec. No. 580 & 731)

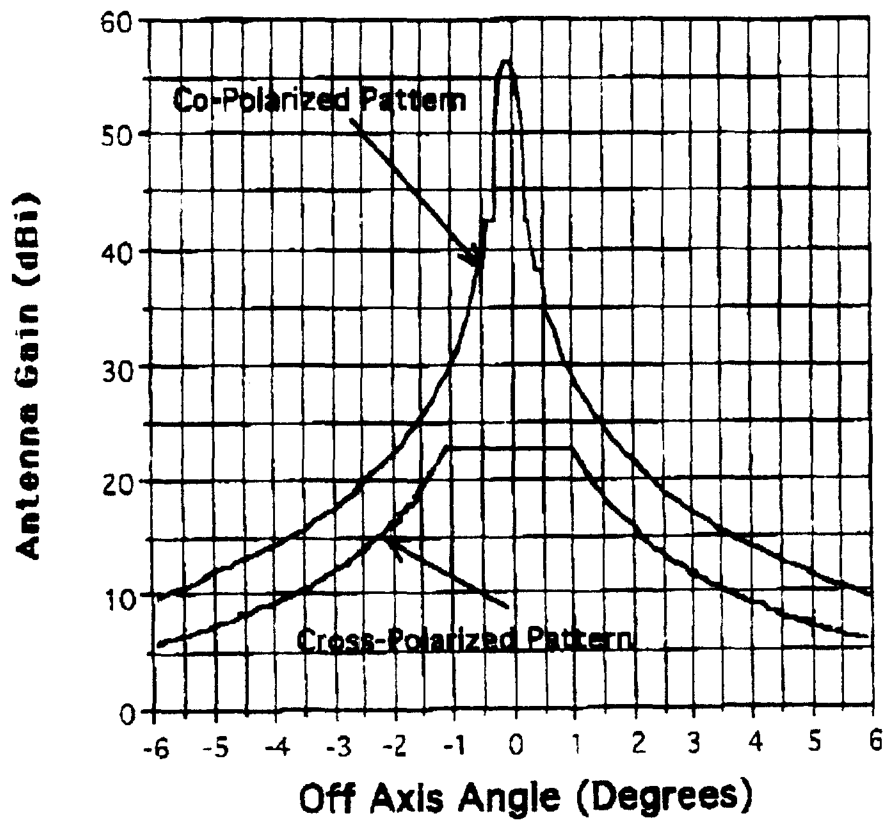


Figure 2-4: The Iridium E/S Receive Co & Cross-Polarized Antenna Patterns
(Based on CCIR Rec. No. 580 & 731)

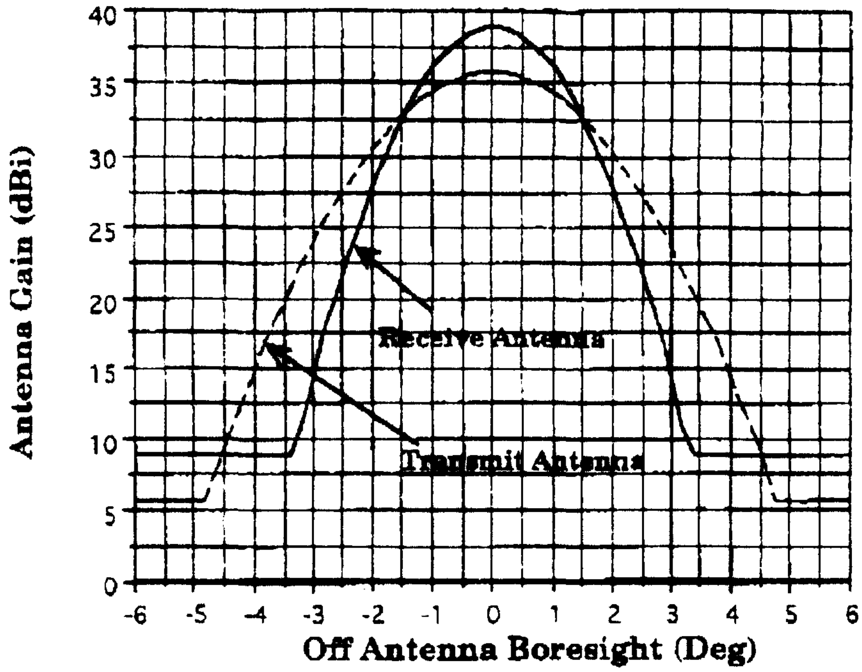


Figure 2-5: The Odyssey™ Receive and Transmit Satellite Antenna Patterns
(Based on CCIR Rec. 558-4)

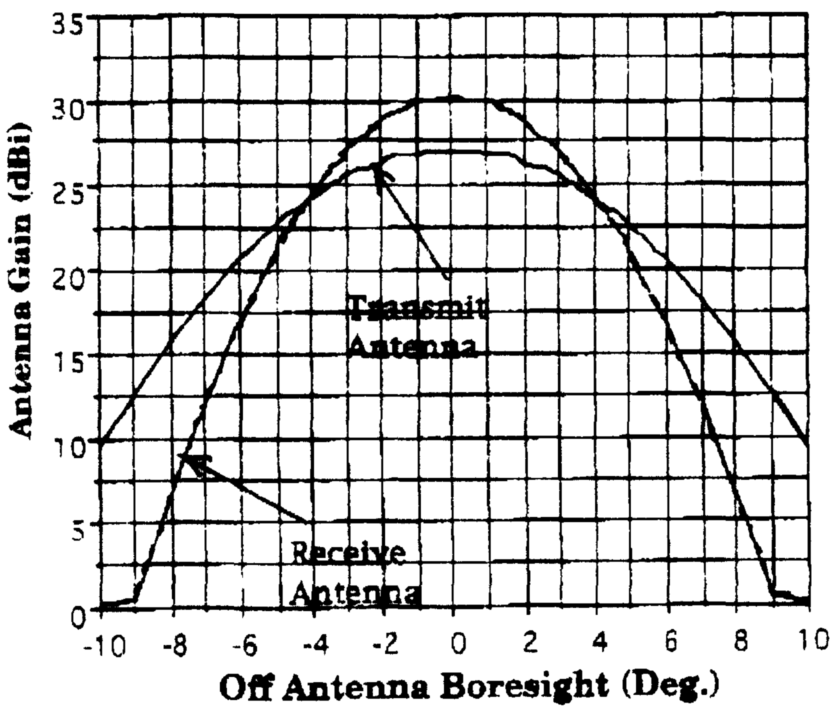


Figure 2-6: The Iridium Receive and Transmit Satellite Antenna Patterns
(Based on CCIR Rec. 558-4)

3.0 Interference Analysis

Analyses were performed of the worst case, single-entry "in-line" interference events of the Odyssey^{TM} satellite feeder links and the Iridium satellite feeder links in the 29/19 GHz band. Two possible interference cases were considered:

Case #1 Uplink interference

- The Odyssey^{TM} (NGSO MEO MSS) Feeder links transmit earth station interfering with the Iridium satellite receiver
- The Iridium (NGSO MSS) Feeder links transmit earth station interfering with the Odyssey^{TM} satellite receiver

Case #2 Downlink interference

- The Odyssey^{TM} satellite transmit antenna interfering with the Iridium earth station receiver
- The Iridium satellite transmit antenna interfering with the Odyssey^{TM} earth station receiver

In each case, the calculated interference level is based on the following assumptions:

* In the United States, it was assumed that the Iridium system would have five earth station facilities. The candidates evaluated were:

  ** Spokane, Washington
  ** Kansas City, Kansas
  ** Montpelier, Vermont
  ** Las Vegas, Nevada
  ** Atlanta, Georgia

* The Odyssey^{TM} system will have no more than eight earth stations world-wide, with two covering the United States. Of the following eight candidate Odyssey^{TM} earth stations, only the potential earth station at San Luis Obispo and Portland were used for purposes of illustration:

  ** San Luis Obispo, CA - USA
  ** Portland, Maine - USA
  ** Buenos Aires, Argentina
  ** Capetown, South Africa
  ** Ahmadabad, India
  ** Marseille, France
  ** Yamaguchi, Japan
  ** Sydney, Australia

Due to the intermittent nature of "in-line" interference, it must be expressed in terms of short term allowances. There are no criteria for acceptable interference levels between two NGSO MSS feeder links.

However, criteria for acceptable interference based on an allowable interference-to-noise ratio (I/N_T) for a given percentage of time was presented in the Report of the Conference Preparatory Meeting to WRC-95 (CPM Report) , CPM95/118 at 43 (Table 8A) (April 1, 1995). The CPM Report specified that the interference due to NGSO MSS feeder link at the input to the demodulator receiving a digital carrier in the GSO/FSS network should not exceed any the following values:

Interference	Maximum % Time Exceeded
Negligible ($\leq$ 6%)	0.87
0.78 N_T	0.119
2.98 N_T	0.0294
14.80 N_T	0.0004

These criteria for acceptable interference are reasonable to use to compute the statistics for the interference between the Odyssey™ system and the Iridium system. However, Iridium has argued that since the Iridium system link availability requirement is 99.9%, the interference threshold I/NT >0.79 should be no more than 0.01% of the time, that means the I/NT = -10.23 dB. We understand that the MSS feeder link requires higher link availability than the service link, but this interference criterion appears to be unreasonably stringent, and will greatly complicate intersystem coordination.

Again, this paper presents the worst case analysis. It assumes that both the Odyssey™ system and the Iridium system transmit at full power under clear sky conditions which is at least 10 to 20 dB higher than normal transmission. We agreed with Motorola that the signal will be de-polarized due to the rain and atmosphere. However, under these conditions, the interference signal that arrives at the satellite or the earth station receiver will be at least 10 to 20 dB lower than the worst case anlysis due to rain and atmosphere attenuations.

Figure 3.1 illustrates the potential interference of the Odyssey™ system and the Iridium system. The receive satellite/earth station antenna of Odyssey™ (or Iridium) receives interference from some of the transmit signal power generated by the transmit earth station/satellite of the Iridium feeder links (or Odyssey™).

The calculated uplink and downlink interference were based on the following:

* All earth station transmit antennas meet the CCIR Recommendation 580
* The estimated satellite antenna patterns were based on the CCIR Recommendation 558-4
* The earth station transmit and receive antenna cross polarized patterns were based on the CCIR Recommendation 731.

Close spacing of the Odyssey™ system ground traces makes it unlikely that the Odyssey™ constellation could be oriented to avoid interference with one or more

Iridium satellites or vice versa . Figure 3-2 shows the 12 satellites in 24 hours of repeating ground traces for the Odyssey™ system. The triangles indicate the positions of the satellites at one time point.

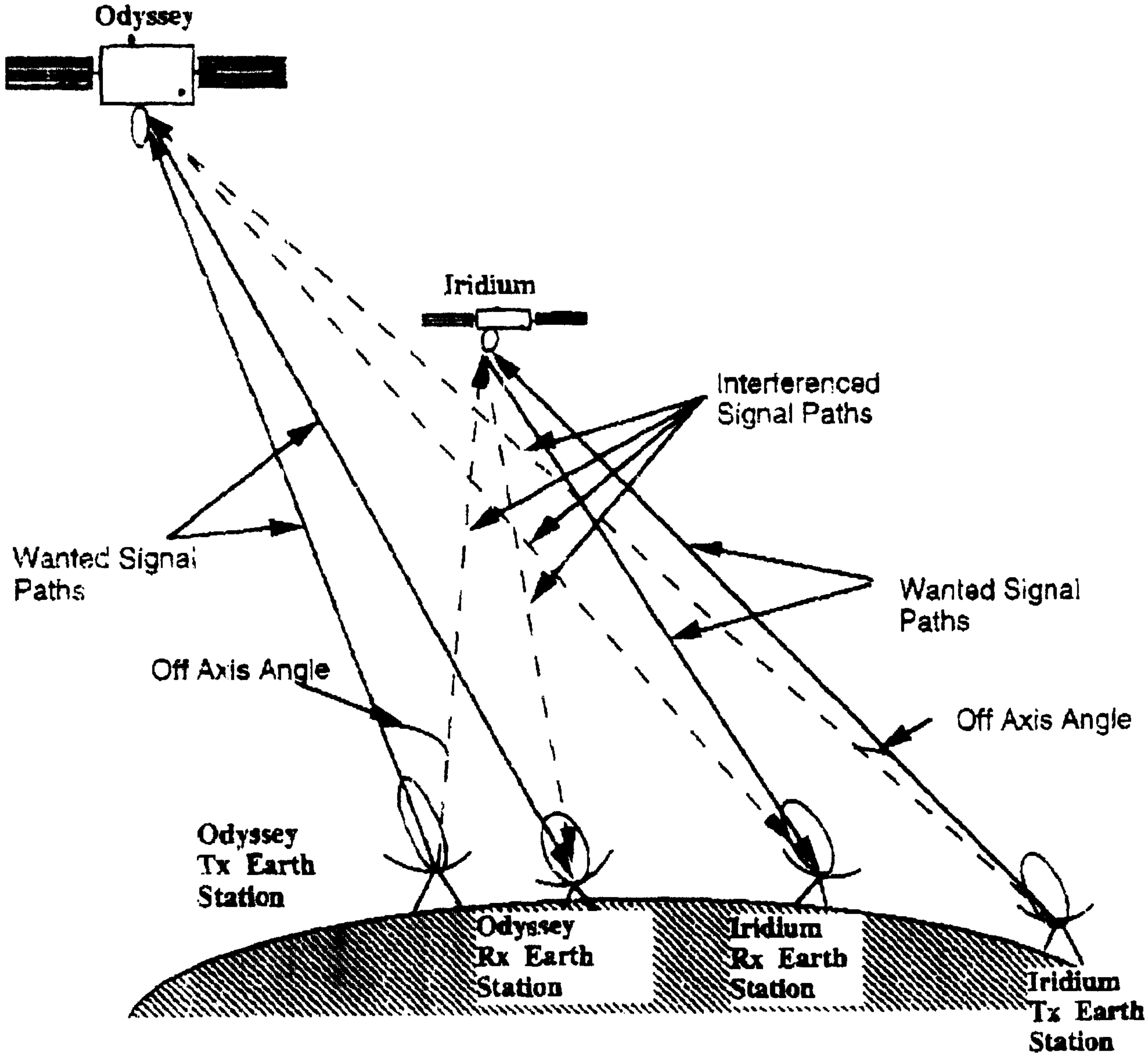
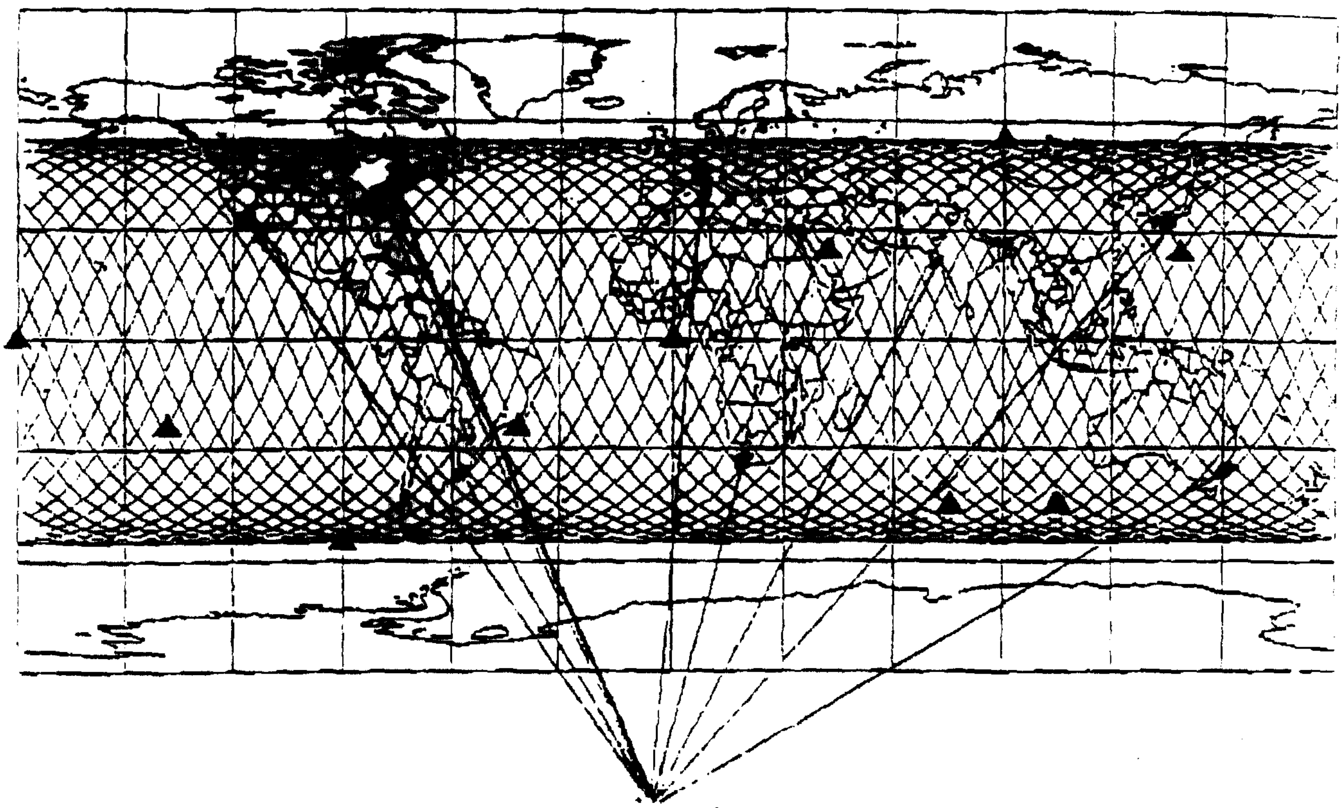


Figure 3.1: Interference Geometry Between The Odyssey™ and The Iridium Networks



Odyssey™ Earth Stations

Figure 3-2: Odyssey™ Ground Trace (12 Satellites, 24 Hour Repeating Ground Traces)

For one case, in which we ran 24 hour repeating ground traces with the 12 - satellite Odyssey™ constellation, all eight Odyssey™ earth stations associated with the 12 Odyssey™ satellites caused "in-line" interference to the Iridium system.

Figure 3-3 shows the number of occurrences versus off axis angle from the Odyssey™ earth station that the Odyssey™ system causes "in-line" interference with the Iridium system.

The maximum "in-line" interference duration between the Odyssey™ system and the Iridium system is shown in Figure 3-4.

For Figures 3-3 and 3-4, to ensure that worst case results are achieved, it was assumed that the Odyssey™ and Iridium earth stations were co-located.

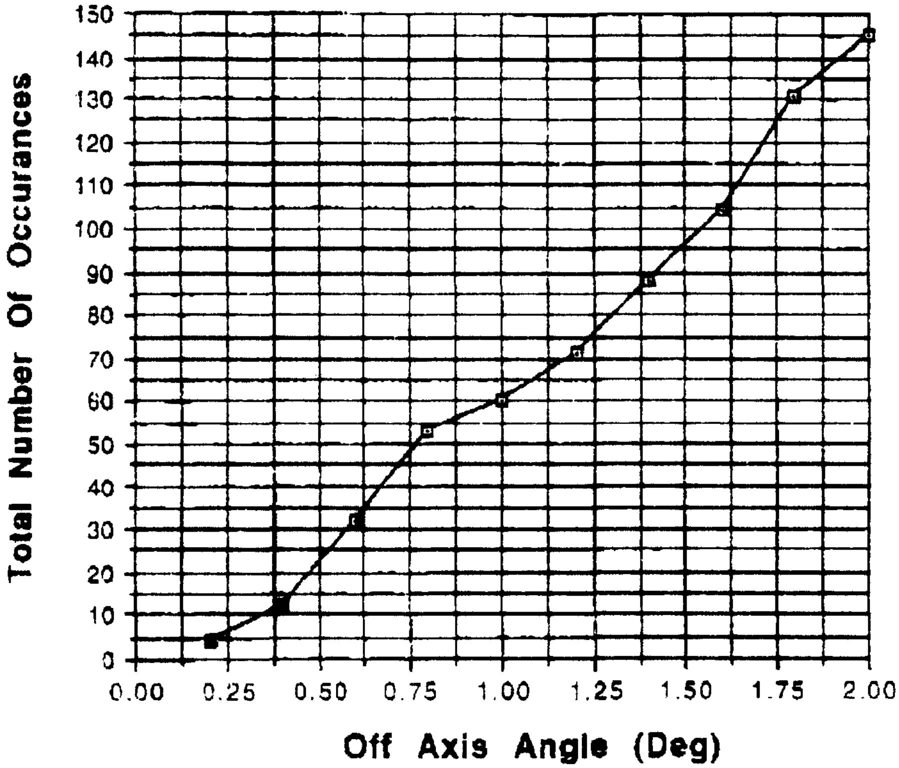


Figure 3-3: Total Number of Occurrences Vs Off Axis Angle

Figure 3-3 can be read as:

* Four Odyssey™ satellites would experience "in-line" interference with Iridium satellites coming within 0.2° off axis angle from the Odyssey™ earth stations.

Figure 3-4 can be read as:

* The maximum interference duration during which the Iridium system would receive interference from the Odyssey™ system is 0.04 minutes at 0.2° off axis angle from the Odyssey™ earth station.

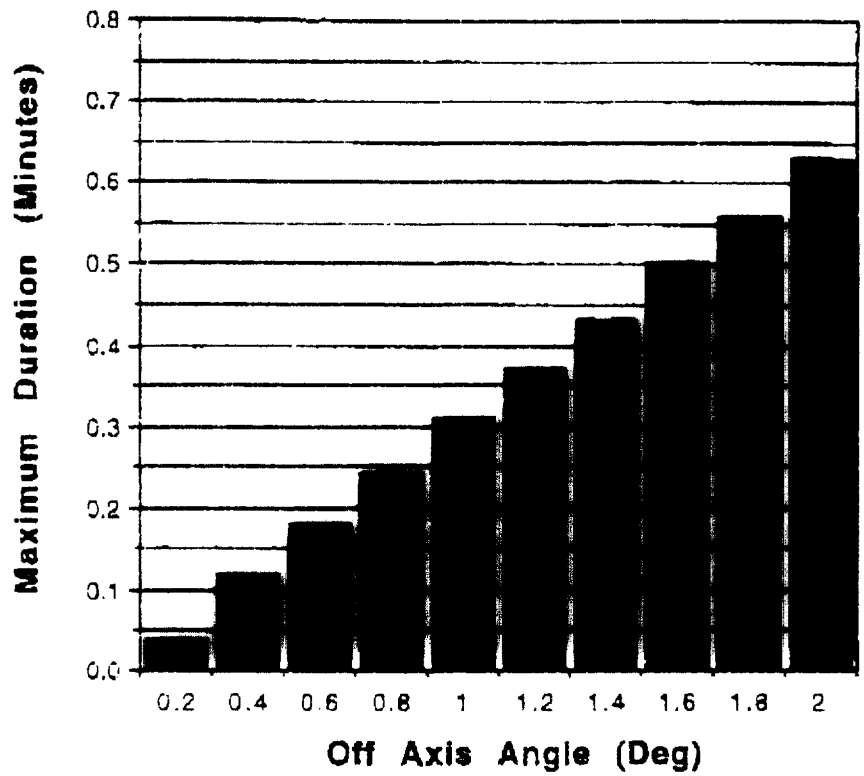


Figure 3-4: Maximum "in-line" Interference Duration Vs Off Axis Angle

3.1 The Potential Uplink and Downlink Interference Between the Odyssey™ System and the Iridium System.

3.1.1 Iridium Victim

Figure 3-5 illustrates the Odyssey™ earth station interference with the Iridium satellite.

Figures 3-6, 3-7, 3-8, 3-9 and 3-10 show the potential interference between the Odyssey™ earth station at San Luis Obispo and the Iridium satellites viewing the Iridium earth stations at Spokane, Kansas City, Montpelier, Las Vegas and Atlanta, respectively.

Figures 3-11, 3-12, 3-13, 3-14 and 3-15 show the potential interference between the Odyssey™ earth station at Portland (Maine) and the Iridium satellites viewing to the Iridium earth stations at Spokane, Kansas City, Montpelier, Las Vegas and Atlanta, respectively.

Figure 3-6 can be read as:

* The Iridium satellite may receive interference from the Odyssey™ earth station at San Louis Obispo associated with the Odyssey™ satellite at 10° elevation angle. However, the separation angle for the Iridium spacecraft viewing of the Iridium earth station at Spokane can be varied from 10 to 30 degrees. More than 90% of the time, the Odyssey™ feeder links elevation angle is greater than 20 degrees. Therefore, the separation angle for the Iridium spacecraft viewing of the Iridium earth station at Spokane is greater than or equal to 20 degrees.

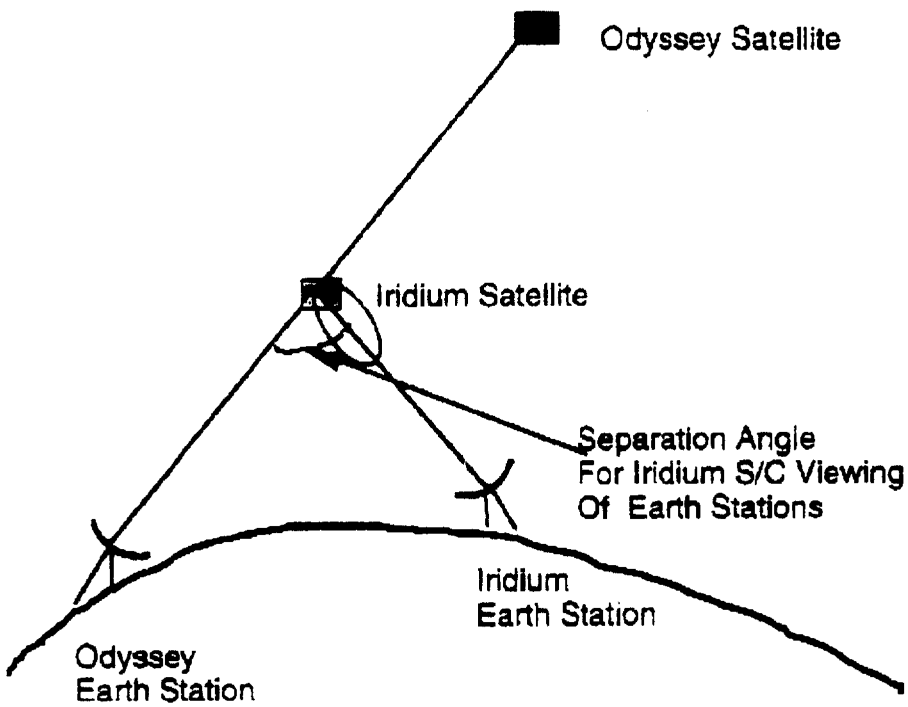


Figure 3-5: Odyssey™ Station Interference With The Iridium Satellites

3.1.1.1 Uplink interference (Interference with Iridium Satellite)

The potential worst case interference is when the Iridium satellites viewing the Iridium earth stations at Montpelier and Las Vegas receive interference from the Odyssey™ earth stations at Portland (Maine) and San Luis Obispo, respectively.

In the calculation, we assume the following:

* Minimum Odyssey™ earth station elevation angle is 10°
* The separation angles are:
  ** Iridium satellite viewing the Iridium earth station at Las Vegas : 9.6°

  ** Iridium satellite viewing the Iridium earth station at Montpelier

S/C Viewing Separation Angle Of Stations
Iridium S/C Viewing of Stations
Station View For San Luis Obispo (Odyssey)
Secondary Station: Spokane (Iridium)
Odyssey Tracking At 5 Minute time Tics

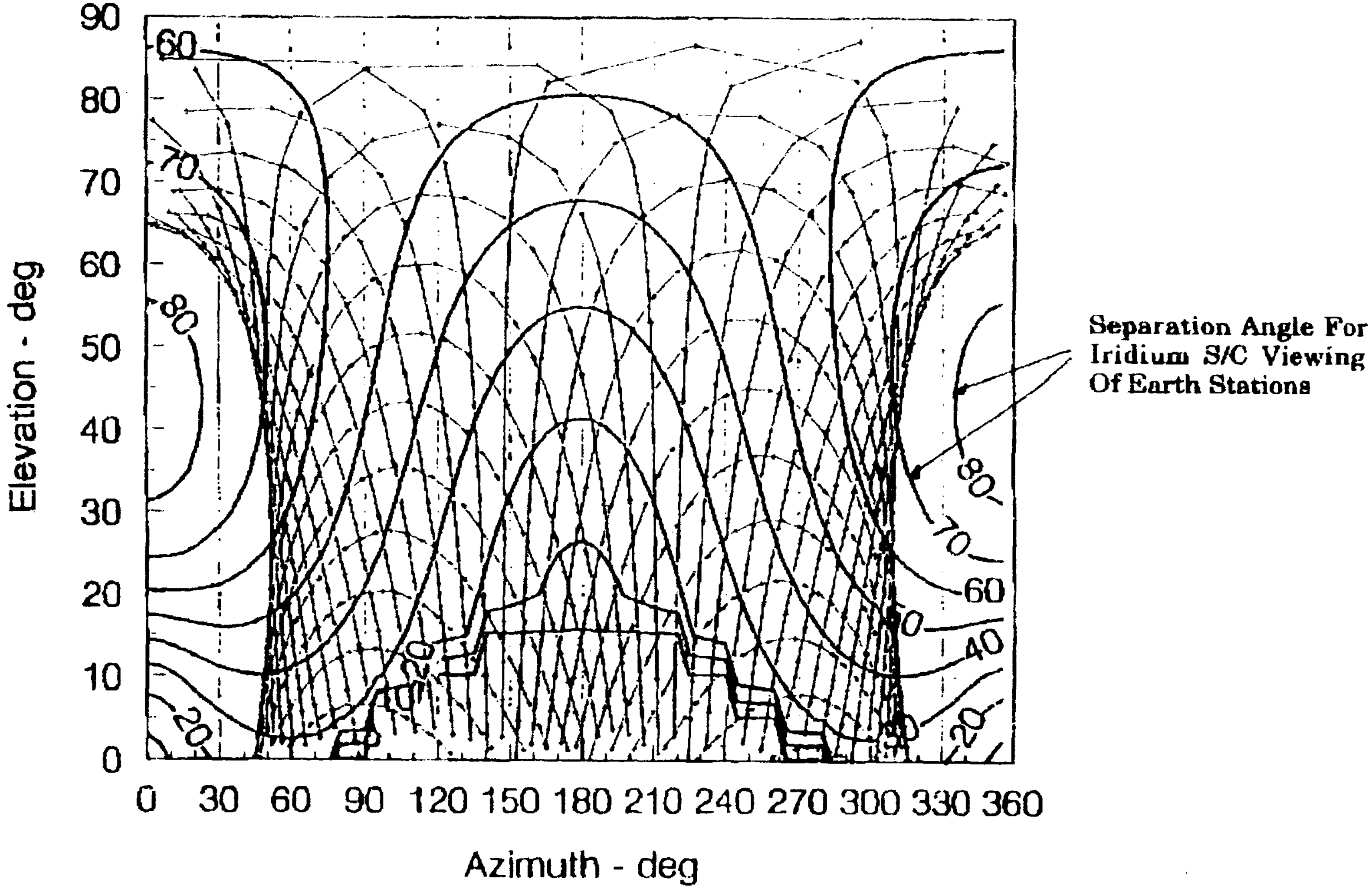


Figure 3-6

S/C Viewing Separation Angle Of Stations
Iridium S/C Viewing of Stations
Station View For San Luis Obispo (Odyssey)
Secondary Station: Kansas City (Iridium)
Odyssey Tracking At 5 Minute time Tics

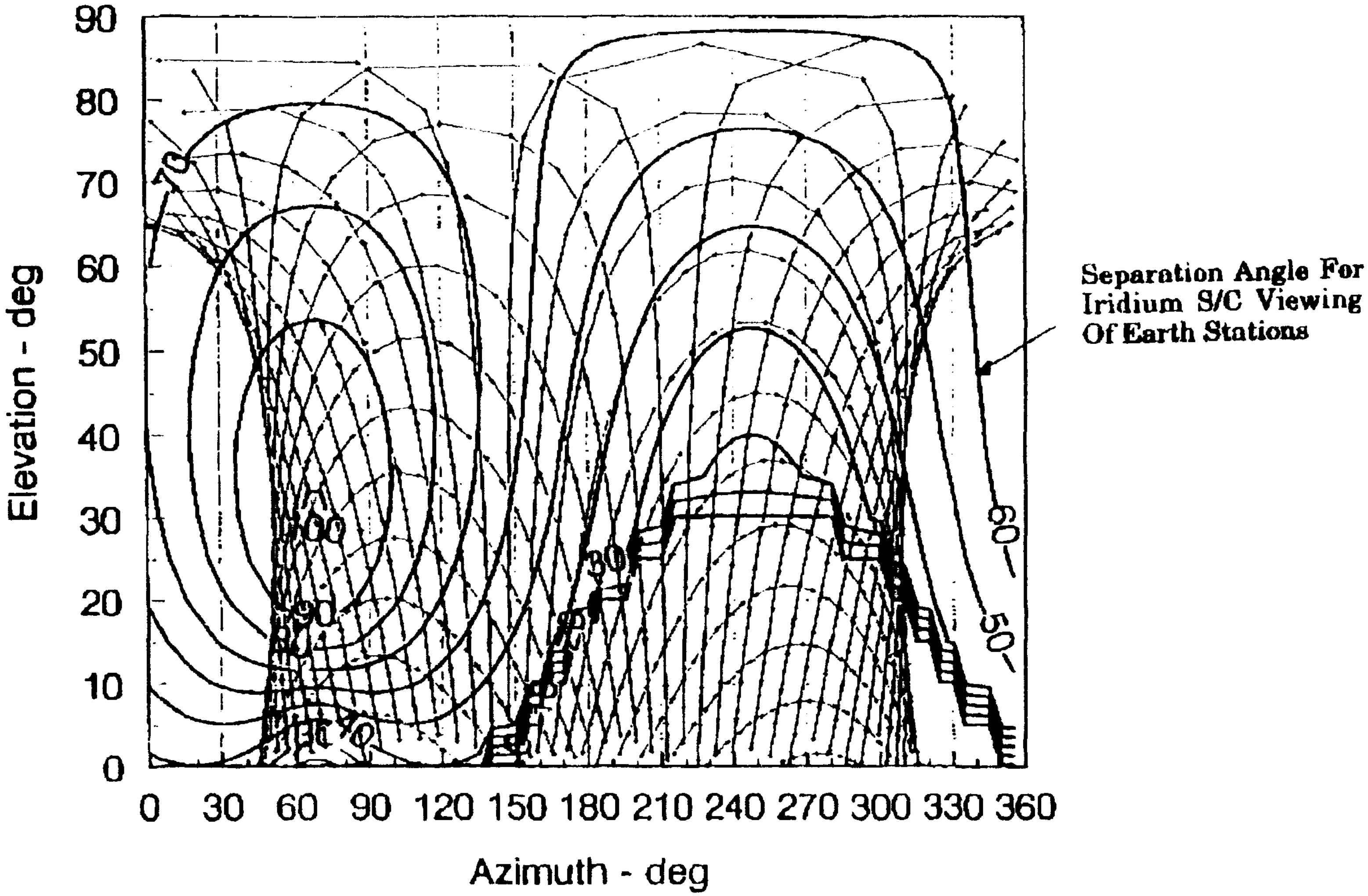


Figure 3-7

S/C Viewing Separation Angle Of Stations
Iridium S/C Viewing of Stations
Station View For San Luis Obispo (Odyssey)
Secondary Station: Montpelier (Iridium)
Odyssey Tracking At 5 Minute time Tics

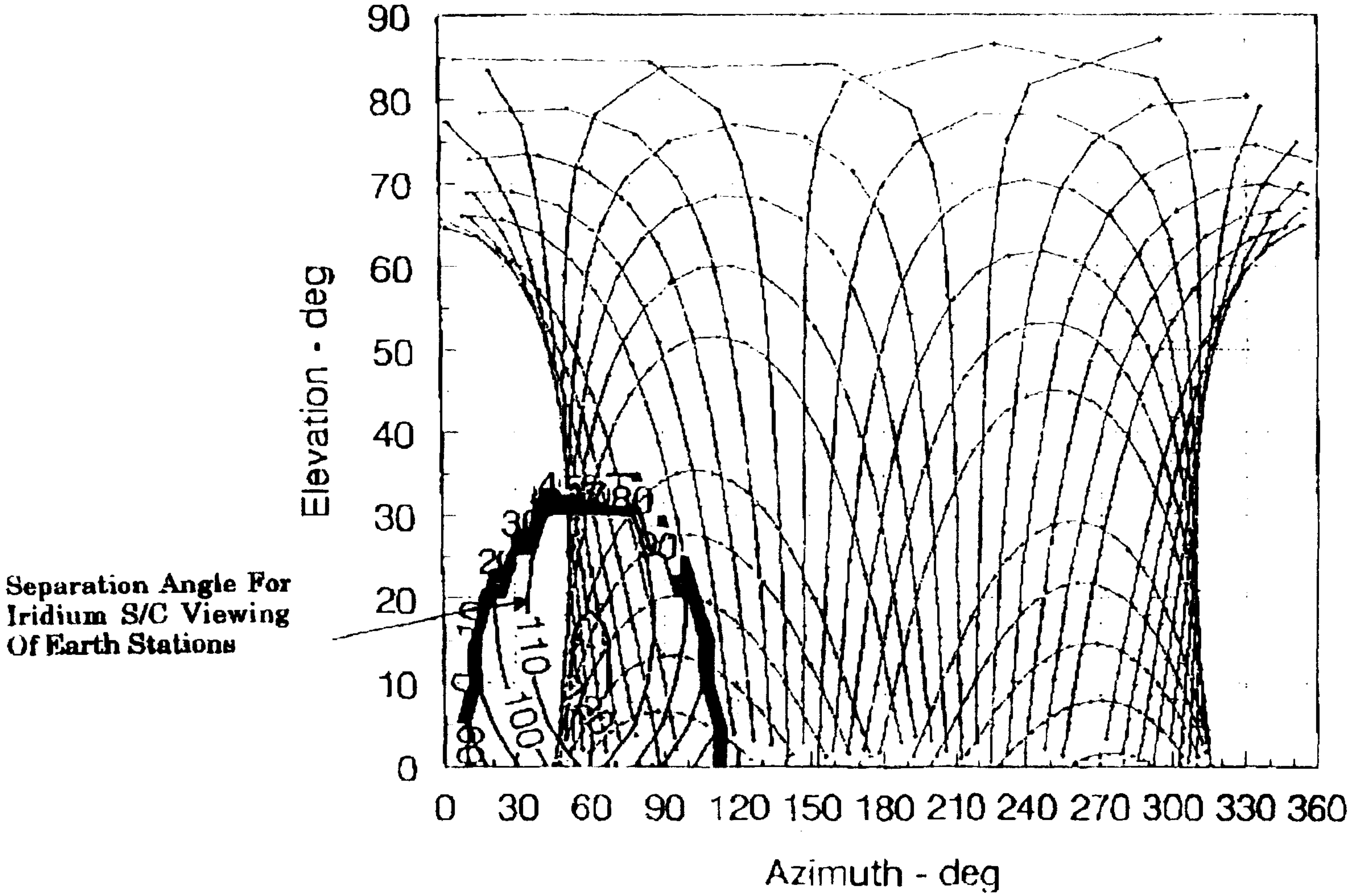


Figure 3-8

S/C Viewing Separation Angle Of Stations
Iridium S/C Viewing of Stations
Station View For San Luis Obispo (Odyssey)
Secondary Station: Las Vegas (Iridium)
Odyssey Tracking At 5 Minute time Tics

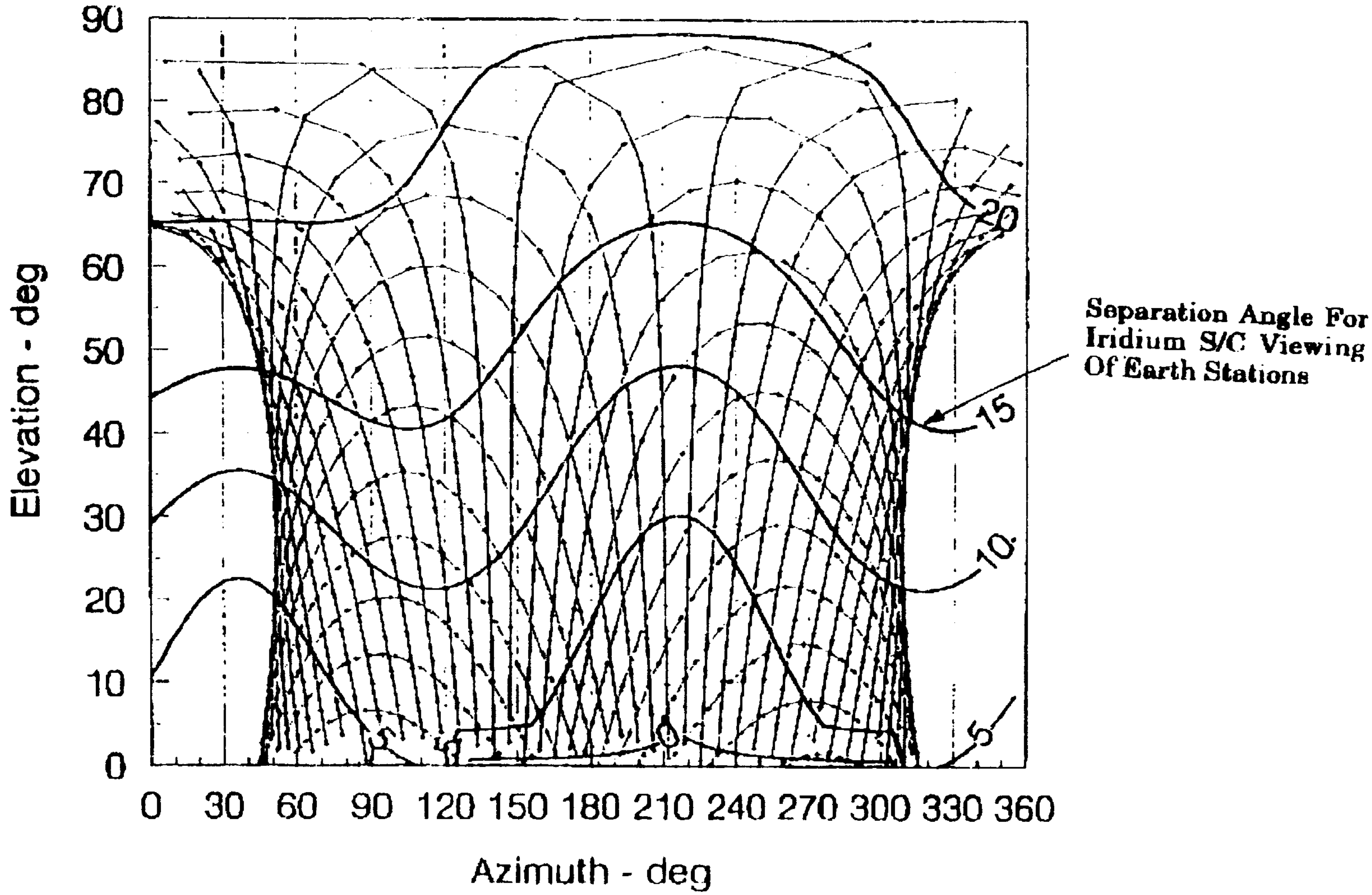


Figure 3-9

S/C Viewing Separation Angle Of Stations
Iridium S/C Viewing of Stations
Station View For San Luis Obispo (Odyssey)
Secondary Station: Atlanta (Iridium)
Odyssey Tracking At 5 Minute time Tics

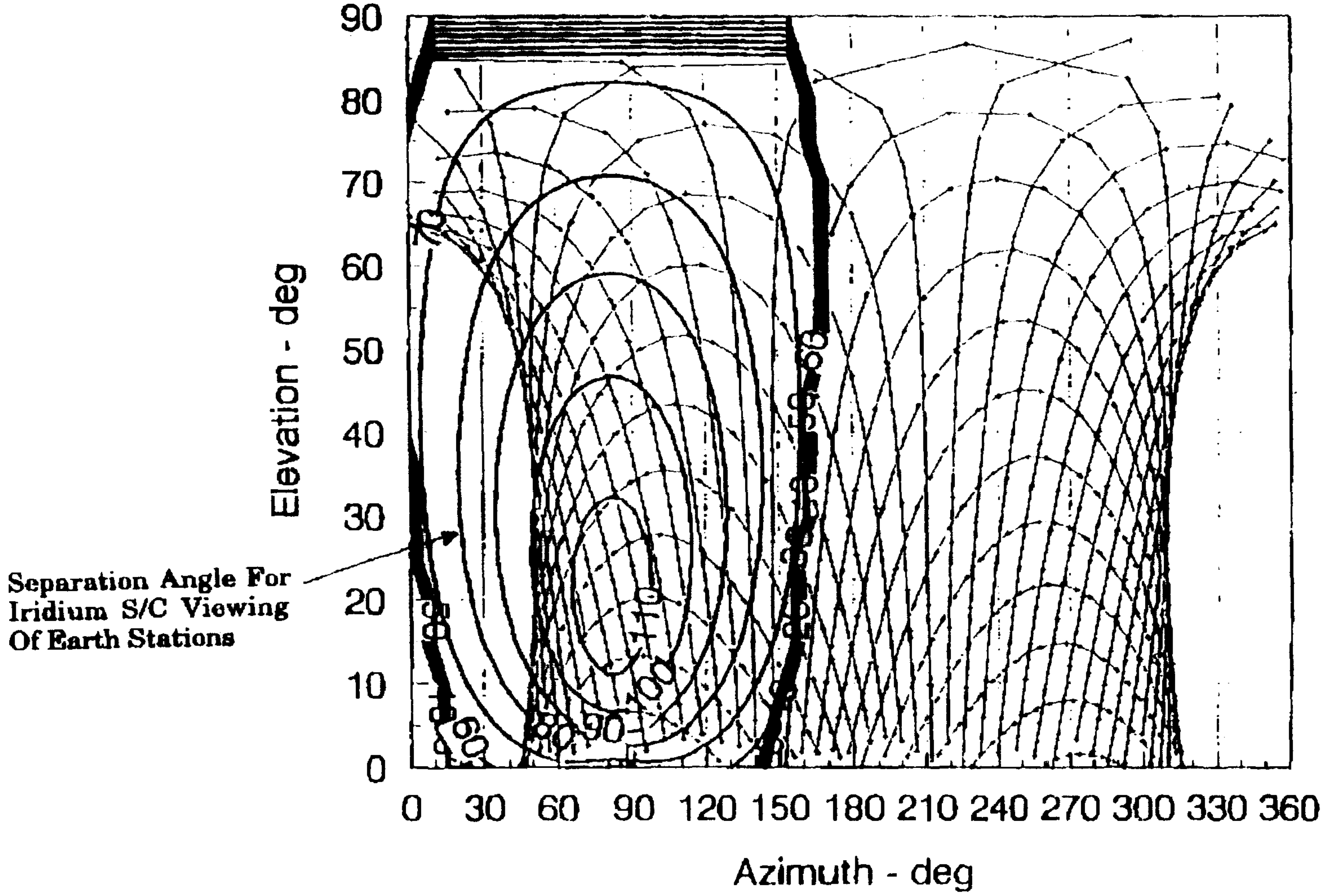


Figure 3-10